HIGH VOLUME FILTER WEIGHT COMPARISON STUDY

A.Q.L. A.B.F. 7402

Ontario

Ministry of the Environment

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INTRODUCTION

The Ontario Research Foundation and Air Resources Branch both operate Hi-Vol sampers at Victoria St., Sarnia. Examination of data derived from samplers operating under similar conditions, on the same days showed that the average loading measured by the Ministry of Environment was approximately 20% greater than obtained by the Ontario Research Foundation.

Possible causes for the difference were discussed at a joint meeting between Air Quality Laboratory and Ontario Research Foundation staff. A comparative study was planned and undertaken to determine the cause of the discrepancy.

The program was divided into three stages:

1. Laboratory comparison of High Volume Sampler calibration procedures.
2. Field comparison of High Volume Sampler calibration procedures.
3. Comparison of glass fibre handling, conditioning and weighting.

The first two stages were carried out as a joint programme between the Air Resources Branch and Ontario Research Foundation. The third stage involved the Air Quality Laboratory and the Ontario Research Foundation.

EXPERIMENTAL

A. High-Volume Sampler Calibration

The High Volume samplers used by the two groups are of the same design but differ in the method of recording

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air flows. The Air Resources Branch samplers use a small calibrated rotameter to read the flow rate. Flows are read at the beginning and end of each run. The Ontario Research Foundation uses a continuous flow recording transducer to determine total air flow. Both groups use similar recommended calibration equipment, supplied by General Metals, which conforms to ASMT D.O.P. Penetration (Method 2986).

Comparison of calibration techniques, when applied to one High Volume Sampler, showed that the Ministry of the Environment and Ontario Research Foundation differed by approximately 17% at 50 c.f.m., the latter group recording the higher flow. This difference would cause the Ontario Research Foundation to record lower particulate loading than the Ministry of Environment. This calibration difference proved to be the largest single source of error found in the comparison study and is covered fully in two reports (1 and 2).

B. Hi-Volume Filter Handling and Verifying Procedures

The study was split into two programmes as follows:

a) Programme I

1. The Air Quality Laboratory prepared and weighed ten (10) filters which were delivered to Ontario Research Foundation staff in Sarnia through normal Air Resources Branch channels.
2. Filters were then conditioned and reweighed by Ontario Research Foundation staff in Sarnia.
3. Filters were exposed by Ontario Research Foundation on the same day Air Resources Branch operated their normal Hi-Vol sampler, then conditioned and reweighed by Ontario Research Foundation at Sarnia and returned to the Air Quality Laboratory through the normal Air Resources Branch route.
4. Filter conditioned and reweighed by Air Quality Laboratory.

b) Programme II

1. The Ontario Research Foundation prepared and weighed twelve (12) filters and delivered them to the Air Qaulity Laboratory.
2. Filters were reweighed by the Air Quality Laboratory.
3. Filters then were delivered to Sarnia and exposed by Air Resources Branch on the same day Ontario Research Foundation operated their High-Volume sampler.
4. Exposed filters were returned to the Air Quality Laboratory, conditioned and weighed.
5. Filters then returned to Ontario Research Foundation for conditioning and reweighing.

The technique employed by the two groups for conditioning High-Volume filters varies slightly as outlined below:

The Ontario Research Foundation use a controlled humidity room operated at 50% relative humidity at $70^{\circ}F$, whereas, the Air Quality Laboratory use a humidity cabinet operating at 52% relative humidity and room temperature to condition exposed High-Volume filters.

Ontario Research Foundation condition unexposed filters prior to weighing. Air Quality Laboratory weigh without pre-conditioning.

The Ontario Research Foundation weighs the exposed filter to constant weight whereas the Air Quality weighs the filter after 16 hours' conditioning in the humidity cabinet.

Each variation of the above techniques will affect data developed by the two laboratories but attention to detail and effective Quality Control should reduce these variations to a minimum.

For Programme I, the Air Quality Laboratory results are given in Table I. Also included are routine Air Resources Branch data for the same time period. Table II gives comparable

results obtained by Ontario Research Foundation. TABLE III gives a summary of results from Programme I. TABLE IV gives the Air Quality Laboratory data for Programme II, Ontario Research Foundation filters exposed on Air Resources Branch samplers. TABLE V gives the Ontario Research Foundation data for the same Programme and TABLE VI the summary of the results for Programme II.

INTERPRETATION

As noted previously, the Air Quality Laboratory staff does not precondition the filter prior to exposure. Comparable tare weights for the unexposed glass fibre filters used in the two programmes are given in TABLE VII. It will be noted that for the First Programme, the unexposed Ontario Research Foundation filters weighed on an average, 3.3 mg. more, than those of the Air Quality Laboratory, and for the Second Programme the average weight was 1.7 mg. higher. The relative humidity of the Air Quality Laboratory Balance Room was approximately 15% for Programme I and approximately 25% for Programme II. For an average particulate loading of 80 $\mu g/m^3$ this would be equivalent to a 1% increase in Total Suspended Particulate.

The Air Quality Laboratory condition the exposed filter in a humidity cabinet but weigh on a balance that has no humidity control. Programme I was carried at a period of low humidity in the Balance Room and could well have accounted for the lower weight obtained by Air Quality Laboratory. Programme II carried out with higher humidity in the Balance Room gave a much closer agreement.

Following these observations, some 18 filters from normal Air Quality Surveys that had been previously weighed in January-February were reweighed in April to measure the effect

of humidity variations. All filters lost weight. The effect of a gain in weight due to increased humidity in April was counteracted by a loss in weight due to filter handling. The filters showed an average weight loss of 1.7%.

In order to check the loss of handling, some 35 exposed filters were conditioned, weighed and mailed to Environment Canada, Ottawa. These filters were immediately returned without opening and then reweighed. This operation took approximately one week and therefore the effect due to local humidity change could be disregarded. The average particulate weight loss due to handling was 2.9%.

Thus, if the loss between January and April analyses due to humidity variations and handling accounted for 1.7% loss, then the loss in weight due to weighing the filters in February as opposed to April could be taken as 1.2%.

The Air Quality Laboratory filters were mailed to the regional office in London and then transferred to Sarnia by a Technician. The Ontario Research Foundation filters were hand delivered at all times and thus subject to less handling loss.

A summary of the cause and extent of the calculated particulate incurred by the Air Quality Laboratory in Programme I when compared with Programme II data is given below.

		% weight loss incurred
1)	Conditioning New filters	1.0%
2)	Humidity effect after transfer of filter from cabinet	1.2%
3)	Filter handling	2.9%
4)	Weighing to constant weight	5.0%
	TOTAL ERROR	10.1%

Assuming that conditions for Program II were near ideal, the above losses account for the total variation found.

Graphs I and II show a plot of comparable particulate weights obtained by the two groups for Programmes I and II.

CONCLUSIONS AND RECOMMENDATIONS

The joint general conclusions from this study are as follows:

The major discrepancy between the Ontario Research Foundation and Air Quality Laboratory High-Volume data was identified as an error in the primary calibration of the High-Volume sampler. This accounts for approximately 17% of the variance. All Ministry Hi-Vols have now been recalibrated.

Differences in handling and analytical procedures exist between the two groups and these account for 5-10% variance in results.

Contributions by the Air Quality Laboratory to this variance are:

1. Lack of controlled humidity for the complete filter weighing operation.

2. Filters are not pre-conditioned at 50% humidity.

3. Filters are not weighed to a constant weight.

4. Large degree of handling takes place in the field before filter reaches laboratory.

RECOMMENDATIONS

1. Investigate possibility for installation of a constant humidity balance room to handle both exposed and un-exposed filters. This will eliminate error due to pre-conditioning and a loss on removal from humidity cabinet.

2. Request Air Resources Branch to revise their filter handling procedures to reduce the number of stages the filters follow and hence reduce particulate loss.

3. Currently The Air Quality Laboratory is following the technique adopted by the Environmental Protection Agency, of conditioning the exposed filter for 16 hours, or overnight, and then weighing. It is not intended to follow the Ontario Research Foundation practice of weighing to constant weight.

REFERENCES:

1) Dr. S. Barton - Ontario Research Foundation Special Report 74-16.

2) P.S.L. Wong - "Calibration of Orifice Calibration Unit for Hi-Vol Samplers".

AQL DATA ON PROGRAMME I AQL FILTER EXPOSED ON ORF SAMPLER

Date 1974	Filter Number 14049	Tare Weight g.	Loaded Weight g.	Weight of Particulates g.	Total Air* Volume m^3	Suspended Particulate Loading $\mu g/m^3$	Concurrent ARB Measurements $\mu g/m^3$
Feb. 4	01	3.6254	3.6538	0.028	870**	33	68
7	02	3.5458	3.5924	0.047	1960	24	-
10	03	3.5411	3.7300	0.190	1970	96	58
13	04	3.5354	3.6577	0.122	1940	63	78
16	05	3.5622	3.6986	0.136	1950	70	-
19	06	3.5728	3.6733	0.101	1915	53	101
22	07	3.5447	3.6275	0.083	1920	43	50
25	08	3.5656	3.7247	0.159	1980	80	144
28	09	3.5596	3.7540	0.194	1920	101	-
Mar. 3	10	3.5705	3.7295	0.159	1930	82	101

* As determined from ORF recording transducer.
** 10 1/2 hours exposure only.

TABLE I

ORF DATA ON PROGRAMME II. AQL FILTERS EXPOSED ON ORF SAMPLER

Date	Filter Number 14049	Filter Weight Clean after g. const. 24 hrs. weight		Filter Weight Exposed after g. const. 24 hrs. weight		Particulates g.	Total Air* Volume m^{-3}	Loading $\mu g/m^3$	Concurrent ORF Measurement $\mu g/m^3$
Feb. 4	01	3.6262	3.6292	3.6554	3.6561	0.029	870	33**	42
7	02	3.5483	3.5493	3.5951	3.5948	0.046	1960	23	23
10	03#	3.5434	3.5446	3.7743	3.7650 3.7637	0.221	1970	112	111
13	04#	3.5372	3.5392	3.6786	3.6744 3.6749	0.137	1940	71	69
16	05#	3.5644	3.5661	3.7226	3.7162 3.7160	0.150	1950	77	74
19	06#	3.5752	3.5767	3.6946	3.6903 3.6899	0.114	1915	60	60
22	07	3.5465	3.5474	3.6397	3.6398	0.092	1920	48	48
25	08	3.5674	3.5685	3.7332	3.7338	0.166	1980	84	81
28	09	3.5618	3.5633	3.7851	3.7859	0.223	1920	116	111
Mar. 3	10#	3.5716	3.5724	3.7649	3.7581 3.7562	0.185	1930	96	88

TABLE II

\# For filters 03-04-05-06-10, a third weighing was considered necessary.

* As determined from recording transducer.

** 10-hour run.

TABLE III

SUMMARY OF RESULTS: PROGRAMME 1

Date	Weight Determinations (mg)			Particulate Loadings µg/m3			
	ORF x	AQL y	ORF/ AQL	ORF Test	AQL Test	ORF Regular	ARB Regular
Feb. 4	29	28	1.03	33	33	42	68
7	46	47	0.98	23	24	23	-
10	221	189	1.17	112	96	111	58
13	137	122	1.12	71	63	69	78
16	150	136	1.10	77	70	74	-
19	114	101	1.13	60	53	60	101
22	92	83	1.11	48	43	48	50
25	166	159	1.04	84	80	81	144
28	223	194	1.15	116	101	111	-
Mar. 3	185	159	1.16	96	82	-	101
		AVERAGE	1.10				

$y = 0.85x + 6.5$

AQL DATA ON PROGRAMME II : ORF FILTERS EXPOSED ON ARB SAMPLER

Date	Filter Number 14049	Tare Weight g.	Loaded Weight g.	Weight of Particulates g.	Air* Volume m^3	Suspended Particulate Loading $\mu g/m^3$
Apr. 2	074001	3.4800	3.7522	0.272	2266	120
5	2	3.4477	3.5235	0.076	2081	36
8	3	3.4533	3.5664	0.113	2102	54
11	4	3.4590	3.8552	0.396	2285	173
14	5	3.4865	3.7264	0.240	2305	104
17	6	3.4790	3.7425	0.264	2224	118
20	7	3.4675	3.7960	0.329	2224	148
23	8	3.4852	3.5972	0.112	2264	49
26	9	3.4735	3.9537	0.480	2015	238
29	10	3.4999	3.7027	0.203	2162	94
May 2	11	3.4958	3.6997	0.204	2122	96
5	12	3.4892	3.6397	0.151	1999	75

* As determined from ARB calibrated rotameter.

TABLE IV

Weight of Unexposed Filter

Filter # 14049	AQL g.	ORF g.	Difference mg	Average Diff. mg
Programme 1.				
01	3.625	3.629	+ 4.0	
02	3.546	3.549	+ 3.0	
03	3.541	3.545	+ 4.0	
04	3.535	3.539	+ 4.0	
05	3.562	3.566	+ 4.0	
06	3.573	3.577	+ 4.0	
07	3.545	3.547	+ 2.0	
08	3.566	3.569	+ 3.0	
09	3.560	3.563	+ 3.0	
10	3.570	3.572	+ 2.0	
				3.3
Programme 11.				
074001	3.480	3.482	+ 2.0	
02	3.448	3.449	+ 1.0	
03	3.453	3.455	+ 2.0	
04	3.459	3.460	+ 1.0	
05	3.487	3.488	+ 1.0	
06	3.479	3.480	+ 1.0	
07	3.468	3.469	+ 1.0	
08	3.485	3.487	+ 2.0	
09	3.474	3.475	+ 1.0	
10	3.500	3.502	+ 2.0	
11	3.496	3.497	+ 1.0	
12	3.489	3.491	+ 2.0	
				1.7

ORF DATA ON PROGRAMME II ORF FILTERS EXPOSED ON ARB SAMPLER

Date	Filter Number 14049	Filter Weight# Clean g.	Filter Weight# Exposed g.	Particulates g.	Total* Air Volume m^3	Loading $\mu g/m^3$	Concurrent ORF Measurements $\mu g/m^3$
Apr. 2	074001	3.482	3.752	0.270	2710	100	104
5	2	3.449	3.524	0.075	2450	31	32
8	3	3.455	3.568	0.113	2730	41	40
11	4	3.460	3.858	0.398	2690	148	125
14	5	3.488	3.728	0.240	2790	86	78
17	6	3.480	3.744	0.264	2790	95	91
20	7	3.469	3.796	0.327	2730	120	122
23	8	3.487	3.599	0.112	2710	41	35
26	9	3.475	3.960	0.485	2770	175	158
29	10	3.502	3.704	0.202	2790	72	88
May 2	11	3.497	3.702	0.205	2860	72	70
5	12	3.491	3.642	0.151	2710	56	50

TABLE V

Final weights.

* Based upon rotameter calibrated with GMW orifice plate kit.

SUMMARY OF RESULTS: PROGRAMME II

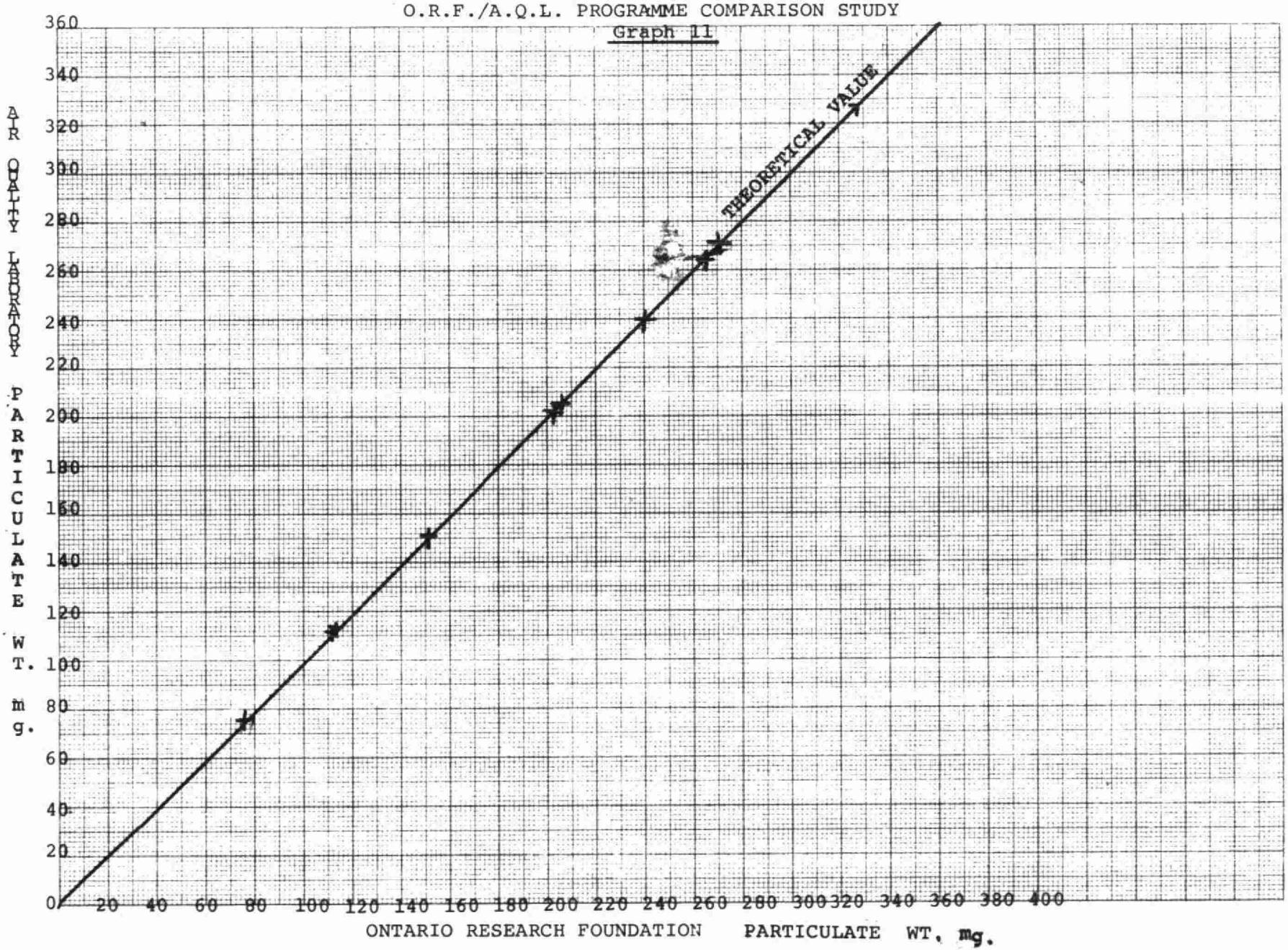
Date	Weight Determinations (mg) ORF x	AQL y	ORF/AQL Ratio	Volume Determinations (m^3) ORF	ARB	Suspended Particulate Loadings ($\mu g/m^3$) ORF Regular	ORF Test	AQL/ARB Test
Apr. 2	270	272	0.99	2710	2266	104	100	120
5	75	76	0.99	2450	2081	32	31	36
8	113	113	1.00	2730	2102	40	41	54
11	398	396	1.01	2690	2285	125	148	173
14	240	240	1.00	2790	2305	78	86	104
17	264	264	1.00	2790	2224	91	95	118
20	327	329	0.99	2730	2224	122	120	148
23	112	112	1.00	2710	2264	35	41	49
26	485	480	1.01	2770	2015	158	175	238
29	202	203	0.99	2790	2162	88	72	94
May 2	205	204	1.01	2860	2122	70	72	96
5	151	151	1.00	2710	1999	50	56	75
AVERAGE	237	237	**0.99**	2728	2170	83	86	109

$y = 0.99 + 2.0$

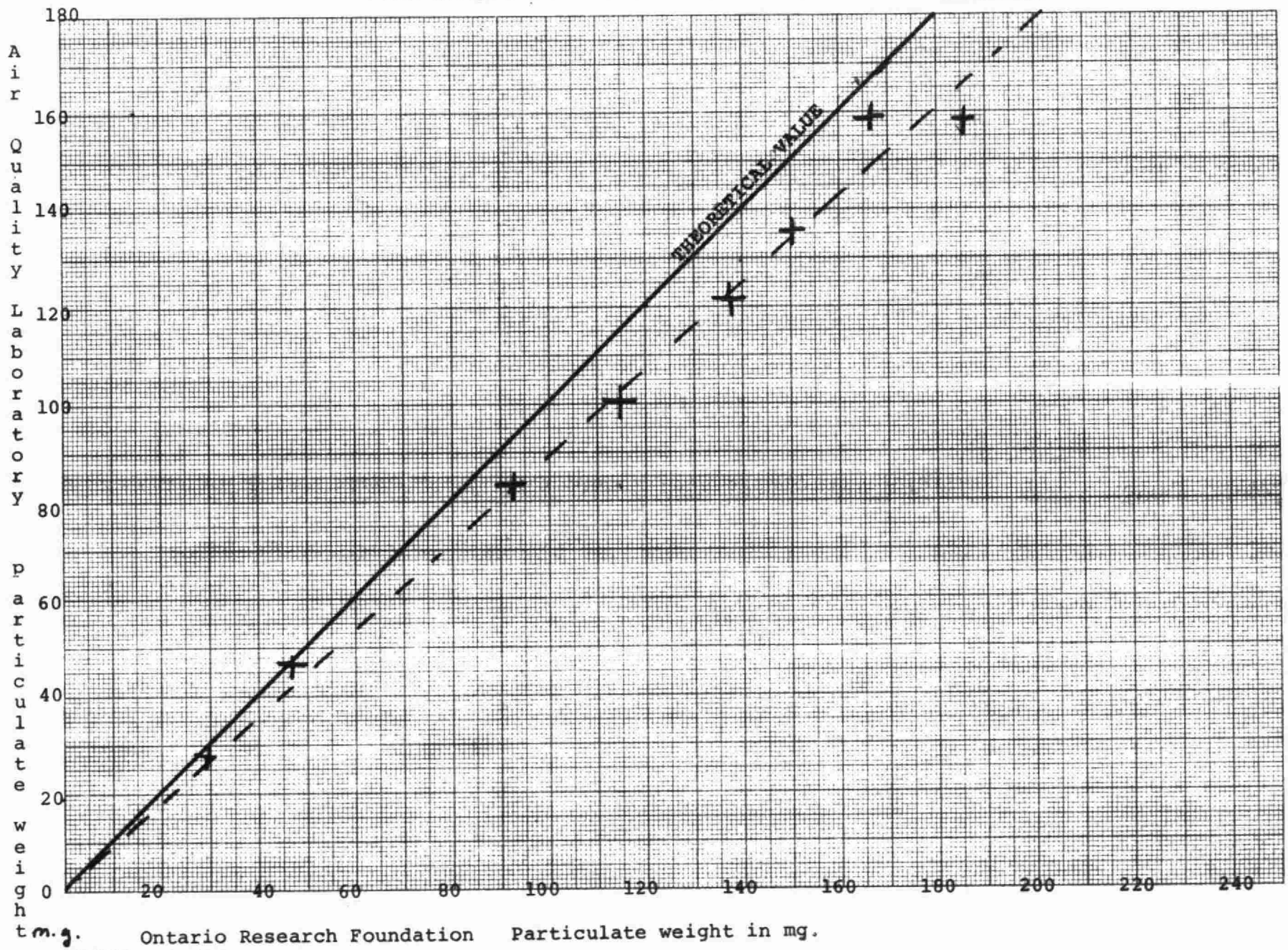
TABLE VI

O.R.F./A.Q.L. PROGRAMME COMPARISON STUDY

Graph 11



O.R.F./A.Q.L. PROGRAMME 1 COMPARISON STUDY Graph 1



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